

# Exhibit 5

## STANDARDS COMPETITION IN THE PRESENCE OF DIGITAL CONVERSION TECHNOLOGY: AN EMPIRICAL ANALYSIS OF THE FLASH MEMORY CARD MARKET<sup>1</sup>

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*Both theoretical and empirical evidence suggest that, in many markets with standards competition, network effects make the strong grow stronger and can “tip” the market toward a single, winner-take-all standard. We hypothesize, however, that low cost digital conversion technologies, which facilitate easy compatibility across competing standards, may reduce the strength of these network effects. We empirically test our hypotheses in the context of the digital flash memory card market.*

*We first test for the presence of network effects in this market and find that network effects, as measured here, are associated with a significant positive price premium for leading flash memory card formats. We then find that the availability of digital converters reduces the price premium of the leading flash card formats and reduces the overall concentration in the flash memory market. Thus, our results suggest that, in the presence of low cost conversion technologies and digital content, the probability of market dominance can be lessened to the point where multiple, otherwise incompatible, standards are viable.*

*Our conclusion that the presence of converters weakens network effects implies that producers of non-dominant digital goods standards benefit from the provision of conversion technology. Our analysis thus aids managers seeking to understand the impact of converters on market outcomes, and contributes to the existing literature on network effects by providing new insights into how conversion technologies can affect pricing strategies in these increasingly important digital settings.*

**Keywords:** Network effects, network externalities, standards competition, conversion technologies, flash memory, digital goods, market competition

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thereby the value of flash memory cards in general (i.e., at an average level of the installed base). When digital converters are available, a consumer who owns a flash memory card of a particular format can exchange data not only with the other digital devices she owns and other devices within the same flash memory network, but also with out-of-network consumers who own digital devices that use incompatible flash memory cards, and can thereby obtain the benefits of compatibility. Figure 2 illustrates the expanded consumer choice set that is afforded by converters. Thus digital converters can increase the consumption utility across flash memory card products of different standards. This implies that greater adoption of digital converters will increase the overall utility for flash memory cards, even if the cards are not compatible. Therefore,

**Hypothesis 2:** *The prices of flash memory cards are positively associated with the adoption of digital converters.*

Our third hypothesis considers the interaction between producers' market power and the introduction of digital converters, and posits that the presence of converters increases product substitutability and thereby reduces the value of flash memory cards, especially for the dominant producers (i.e., those with an installed base that is larger than average). When making a technology choice, the wide presence of digital converters reduces the consumer's risk of being stranded on a new, but less popular standard, as the chances for survival of a new technology are larger when network effects are less significant. In addition, digital converters allow consumers who own incompatible products to exchange data with each other. As a result, when digital converters are widely present consumers are not as motivated to purchase a dominant standard as there is less benefit from it; this lowers the producer's market power and, consequently, its price premium due to network effects. Following this logic in the context of flash memory cards, a greater adoption of digital converters will especially affect the price of the dominant standard. Producers of flash memory card standards with a larger installed base are expected to lose more market power than those with a smaller installed base, as they have more value to lose from being a dominant standard when converters are present. Thus, we expect that

**Hypothesis 3:** *The adoption of digital converters reduces the impact of the installed base on flash memory card prices such that the price reduction effect is stronger for products with a larger installed base than for products with a smaller installed base.*

Finally, in Hypothesis 4, we consider the effects of digital converters on market concentration for flash memory card

producers. Classic network effects theory predicts that product markets will tip toward a single dominant standard when there are strong network effects. Consequently, market concentration will typically increase once the installed base of the leading standard has reached a critical mass. However, as argued here, it is possible that the presence of conversion technology will affect the nature of competition, as conversion technology can offset some of the impact of network effects. If this is true, it is less likely that a dominant producer will emerge in a market with an increasing presence of converters. The flash memory card market could then be expected to be less likely to tip toward one dominant producer as many different formats can be converted to become compatible. Therefore,

**Hypothesis 4:** *Market concentration of flash memory card producers decreases as the adoption of digital converters increases.*

Figure 3 summarizes these four hypotheses and illustrates the conceptual framework for our empirical analysis along with the predicted directions of the hypothesized interaction between the adoption of digital converters and a product's installed base. This figure also illustrates two important market outcomes: card price and market concentration. Control variables are shown in dashed boxes.

## Data and Measures

### Sample

To test our hypotheses, we assembled a large panel data set including data on flash memory card products and their producers. We selected a sample period from 2003 to 2006 for our analysis as this is a critical period in the development of the flash memory card market during which all six major formats are present. Our primary data were generously provided by the NPD research group. These data include detailed information on monthly retail prices and unit sales data of the major flash memory cards and digital converters sold each month by major U.S. retailers. These data are obtained by NPD directly from point-of-sale (POS) terminals in major retailers across a range of outlets and cover the period January 2003 to August 2006.

To supplement the NPD data set, we also implemented a software agent to retrieve daily observations of flash memory card prices, sales rank, and product review data from Amazon.com. We use the customer review ratings to control for the reputation of different flash memory card models, and we use the price data to validate the retail prices from the NPD data set. Finally, we gathered the flash memory cards'